(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) Publication number: 0 052 342
B1

(12) EUROPEAN PATENT SPECIFICATION

(45) Date of publication of patent specification: 30.07.86

(51) Int. Cl.[4]: G 06 F 15/20

(21) Application number: 81109630.4

(22) Date of filing: 11.11.81

(54) Data processing device for computed tomography system.

(30) Priority: 17.11.80 JP 160908/80

(43) Date of publication of application:
26.05.82 Bulletin 82/21

(45) Publication of the grant of the patent:
30.07.86 Bulletin 86/31

(84) Designated Contracting States:
DE FR IT NL

(58) References cited:
IEEE TRANSACTIONS ON COMPUTERS, vol.C-29, no.5, May 1980, New York (US) E.E. SWARTZLANDER et al.: "Arithmetic for ultra-high-speed tomography", pages 341-353

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EP 0 052 342 B1

Courier Press, Leamington Spa, England.

Description

The present invention relates to a data processing device which is applied to a computed tomography system and calculates and processes projection data for image reconstruction and, more particularly, to a data processing device which calculates and processes projection data for image reconstruction according to a back-projection technique to convert the data into data for two-dimensional slice images.

Images obtained in a computed tomography scanning system (hereinafter referred to simply as "the CT system") are not converted into forms which we can understand (that is, visual images) until calculation and processing for image reconstruction are performed. In this sense, an image reconstruction device plays an extremely important role in the CT system. In general, the CT system consists of three subsystems: 1. a data acquisition subsystem, 2. an image reconstruction subsystem and 3. an image display and evaluation subsystem. In this image reconstruction, the projection data are obtained from detectors which rotate corresponding to the rotation of an X-ray source (so-called ROTATE/ROTATE system) and are disposed in opposition to this X-ray source with an object to be examined being interposed therebetween. The projection data are processed by a computer and converted into so-called CT numbers. The data for tomograms are formed from these CT numbers. The back-projection technique is one of the algorithms used for image reconstruction. The principle of the back-projection operation for getting the original image or picture is disclosed in document US—A—4,219,876. In other words, the back-projection calculation is composed of a repetition of basic accumulation. The numbers of projection data and of display picture elements (hereinafter referred to as "pixel") have lately tended to increase to enable reconstruction of more precise images. Therefore, the amount of calculation executed by the data processing device for reconstruction processing has been still further increased. However, the scanning time in the data acquisition subsystem has been reduced to several seconds. Thus, it becomes necessary to correspondingly shorten the time for image reconstruction from the viewpoint of improvement in cost/performance of the CT system. Consequently, the CT system especially needs a data processing device which not only has a large calculating capacity, but also calculates at a high speed.

In a data processing device applied to a conventional CT system, matrix data consisting of 320 columns × 320 rows, for example, are sequentially accumulated for every projection (for example, 600 projections as a whole) and stored in a memory (image memory). Then, the image reconstruction is performed according to the back-projection technique mentioned above. However, since the projection data are sequentially accumulated and processed for each of the 600 projections in the conventional data processing device, at least 600 memory accesses must be made for each row. The greater the number of memory accesses, the longer becomes the total access time, unless each memory access is speeded up. On the other hand, there is a predetermined limit to the access speed in the image memory. For the reasons described above, such a data processing device is defective in that the speedup of data processing is prevented.

In order to overcome this defect, it may be possible to employ a back-projection data generating section of the data processing device as a multiplex system and to simultaneously read out (interleave) a plurality of words stored in the image memory so that the speedup of data processing is realized. However, when the interleaving reaches or exceeds a certain limit, it becomes difficult to effectively use the image memory with regard to its capacity, which raises a problem of economy. A 16-bit IC memory is now generally considered to be economical as a single unit. However, when the image memory formed of 16-bit IC memory is multiplexed and interleaving above some limit is executed as described above, the area of the IC memory situated in the direction of the column becomes unavailable, and this produces much waste. In addition, the economic loss is increased, since the number of IC memories used is increased.

Furthermore, document "IEEE Transactions on Computers", Vol. C-29, No. 5, May 1980, pages 341 to 353 discloses a CT system in which a reconstructor having a convolution filter and back projector performs filtered back-projection for high-speed CT image reconstruction. Both of the convolution filter and back projector are concerned with an interleave process. In other words, in the known CT system a plurality of multipliers are used to simultaneously perform data multiplication and the resultant data is then added, thereby reducing the time for the multiplication. In particular, the back projector temporarily stores, for example, 28 pieces of convolved projection data in 28 profile memories. With data, which is obtained on the basis of the projection data, being weighted, the values of individual pixels to be back-projected are summed for image reconstruction. That is, the back projector produces all the back projection data and then sums the back projection data at one time in order to increase the processing time. The method described capitalizes on the inherent computational parallelism of the filtered back projection algorithm. However, the addition/multiplication of back-projection data is performed only after all the back-projection data is obtained. In the known CT system, as the number of projections increases, the number of the profile memories and multipliers has to be increased to that number of projections. Normally, there are about 600 projections. Therefore, the greater the number of projections, the more complex the system arrangement becomes.

The present invention has for its object to provide a data processing device of a computer applicable to a CT system, which can improve the accumulation speed and thereby still further speed up the data processing, without reducing the economy of the device.

In order to solve this object, the present invention provides a data processing device which is applied to a computed tomography system for examining at least one portion of an object by utilizing radiation such as X-rays and which processes data from a plurality of projections for image reconstruction, wherein the computed tomography system includes detector means positioned opposite a radiation source means through the object, for detecting radiation output from said radiation source means, and means for effecting a relative rotation between the object and said radiation source means about an axis of rotation, said data processing device comprising first processing means for successively generating N sets of back-projection matrix data based on outputs derived from said detector means at N angles of said rotation, where N represents a positive integer, said data processing device being characterized in that it comprises also second processing means, connected to said first processing means, for summing successive n sets of back-projection matrix data among said N sets of back-projection matrix data, and for successively providing summed data, where n is a positive integer, image memory means for temporarily storing calculation result data; and third processing means connected to said second processing means and said image memory means for successively receiving the summed data for k times (k = N/n), where k is a positive integer and sequentially adding said summed data in such a manner that said third processing means repetitiously performs an arithmetic operation of adding that summed data which is currently supplied to said third processing means to that summed data which is currently stored in said image memory means and replacing said summed data stored in said image memory means with new summed data resulting from said addition of said third processing means, thereby finally permitting said image memory means to store a final value of said N sets of back-projection matrix data, whereby the number of write-operations of said image memory means, which are required to attain said N sets of back-projection matrix data, is reduced substantially to N/n so that a back-projection time necessary for image reconstruction is reduced, accordingly.

The data processing device of the present invention is applied to a computed tomography system which examines at least one portion of a living body utilizing radiation of X-rays or the like, and processes data from a plurality of projections. This data processing device comprises a first processing means for receiving electrical tomography signals corresponding to radiation which has penetrated the living body to sequentially generate N matrix data on the basis of these signals. Each matrix of data has i columns and j rows. It is to be noted that the letters N, i and j indicate positive integers (that is, natural numbers). The data processing device further comprises a second processing means for substantially dividing the N matrix data into k data groups with n of the N matrix data being defined as one unit group, and for respectively calculating the partial sums of these k data groups; and a third processing means connected to the second processing means for sequentially accumulating the partial sum data of the k data groups to calculate the total sum of the N matrix data mentioned above. Similarly, it is assumed that the letters n and k indicate natural numbers and satisfy the conditions: $n < N$ and $k = N/n$.

This invention can be more fully understood from the following detailed description when taken in conjunction with the accompanying drawings, in which:

Fig. 1 schematically shows the overall construction of a CT system including a data processing device according to one embodiment of the present invention;

Fig. 2 shows a simulated view of projection data which are divided into a plurality of blocks according to the present invention;

Fig. 3 shows the internal construction of the data processing device of Fig. 1;

Fig. 4 shows the internal construction of a partial sum-calculating unit included in a partial sum-producing section provided in the data processing device of Fig. 3;

Fig. 5 shows the internal construction of an accumulator included in an accumulation section shown in Fig. 3; and

Fig. 6 shows a timing chart for explaining the operation mode of the data processing device of Fig. 1.

The overall construction of a CT system including a data processing device 10 according to an embodiment of the present invention is shown in Fig. 1. An X-ray source 12 incorporates, for example, a known X-ray controller, a high-voltage generator, a high speed starter, an X-ray tube and so on, none of which is shown. From this X-ray source 12 is produced a pulsating X-ray beam 14 under the conditions that the tube voltage is 120 kV and the tube current is 30 mA, for example. The fun-shaped X-ray beam 14 generated by the X-ray source 12 penetrates a wedge filter 16 and a subject 18 such as a human body (region of interest, ROI) and reaches an X-ray detecting section 20. This X-ray detecting section 20 serves to produce electric signals accurately corresponding to the intensity characteristic of the X-ray dose which has penetrated the subject 18. The detecting section 20 is comprised of a plurality of detector elements, for example 320, detector elements 20-1, 20-2, ..., 20-320 which are arranged along an arc line of predetermined radius. In each of these detector elements 20-1, 20-2, ..., 20-320 is charged high pressure Xenon (Xe) gas. Electrons produced by ionization caused by the X-rays incident on the respective elements are collected in an electrode, not shown. An electric signal which is substantially proportional to the energy of the incident X-ray is output from each detector element.

The electric signals (analog signals) output from the X-ray detecting section 20 are transmitted to a data acquisition section 22. This data acquisition section 22 is also comprised of a plurality of channels whose number is equal to that of the detector elements constituting the X-ray detecting section 20, that is, 320. This data acquisition section 22 serves to convert the analog electric signals into digital signals. The data acquisition section 22 includes, for example, a known signal amplifier, a sampling and holding circuit, a multiplexer, an A/D converter and so on, none of which is shown. The digital signals (matrix data) output from the data acquisition section 22 are transferred through a control unit 24 provided in an image reconstruction device 26, and temporarily stored in an external memory 28. After being read out from this external memory 28 at a predetermined time, these matrix data are input to the data processing device 10 of the present invention in a known manner. The data processing device 10 includes a matrix data-generating section 30, a partial sum-producing section 32 and an accumulation section 34. As shown in Fig. 2, the matrix data which correspond to 600 projections P1, P2, . . ., P600, for example, form one data aggregate 36 as a whole. Each projection corresponds to matrix data collected into a matrix consisting of 320 columns × 320 rows. The data processing device 10 divides the aggregate 36 of matrix data into a plurality of groups, each of which is defined to contain four projections as one unit, for example. It then calculates a partial sum for each divided data group 40-1, 40-2, . . ., 40-150. The calculation for image reconstruction is performed according to the back-projection technique by sequentially accumulating these partial sums to obtain the total sum.

In Fig. 3, the internal construction of the data processing device 10 of the image reconstruction device 26 shown in Fig. 1 is illustrated. In this data processing device 10, one data group which is shown in Fig. 2 and corresponds to four projections is processed in the partial sum-producing section 32 as multiplexed fourfold. The matrix data-generating section 30 includes four (first to fourth) matrix data generators 30-1, 30-2, 30-3 and 30-4 which are connected in parallel with each other. The data of four projections forming one block are acquired in the matrix data-generators 30-1, 30-2, 30-3 and 30-4. These data generators 30-1, 30-2, 30-3 and 30-4 are respectively connected to four (first to fourth) partial sum-calculating units 32-1, 32-2, 32-3 and 32-4 which constitute the partial sum-producing section 32 and are connected in parallel with each other. The data stored in each matrix data generator are sequentially input to these four calculating units 32-1, 32-2, 32-3 and 32-4. The output ends of the partial sum-calculating units 32-1, 32-2, 32-3 and 32-4 are connected to the accumulation section 34 described above. This accumulation section 34 is composed of four (first to fourth) accumulators 34-1, 34-2, 34-3 and 34-4. The data stored in the partial sum-calculating units 32-1, 32-2, 32-3 and 32-4 are respectively sequentially input to these four accumulators.

Fig. 4 shows the construction of any one of the four partial sum-calculating units 32-1, 32-2, 32-3 and 32-4 constituting the partial sum-producing section 32, for example, that of the calculating unit 32-1. The other calculating units have the same construction as this calculating unit 32-1. An output from the matrix data-generating section 30 is transmitted to one input end of an adding circuit 42. The output of this adding circuit 42 is transmitted to the accumulation section 34 (Fig. 3) and also to a multiplexer 46 through a partial sum memory 44. When the first projection is processed, the multiplexer 46 outputs a zero level signal which is transmitted to the other input end of the adding circuit 42. When the subsequent projections are processed, the data stored in the partial sum memory 44 are output from the multiplexer 46. These data are input to the other input end of the adding circuit 42 as matrix data. The adding circuit 42 adds and processes the output data from the matrix data-generating section 30 and the output data from the multiplexer 46. In addition, a known address counter 48 is connected to the partial sum memory 44. To this counter 48 are supplied in a known manner clock signals, reset signals and so on, which are not shown.

Fig. 5 shows the construction of any one of the four accumulators 34-1, 34-2, 34-3 and 34-4 constituting the accumulation section 34 shown in Fig. 2, for example, that of the accumulator 34-1. The remaining accumulators have the same construction as this accumulator 34-1. The output from the partial sum-producing section 32 is fed to one input end of an adding circuit 54 through a register 50 of a first stage and a register 52 of a second stage. The output from this adding circuit 54 is supplied to an image memory 56 and stored therein. The output data of the image memory 56 are transmitted to an image display device 60 (Fig. 1) or the like shown in Fig. 1, and are also transmitted to the other input end of the adding circuit 54.

When first column data R1 of the first to fourth projections P1, P2, P3 and P4 included in the first divided data group 40-1 (Fig. 2) are processed in one of the four calculating units included in the partial sum-producing section 32, for example, in the first partial sum-calculating unit 32-1, second column data R2 of the first to fourth projections P1, P2, P3 and P4 are processed in the second partial sum-calculating unit 32-2 according to a timing which is delayed by one unit time interval. During these processing operations, the third partial sum-calculating unit 32-3 processes the third column data R3 of the first to fourth projections P1, P2, P3 and P4 contained in the first divided data group 40-1 according to a timing which is further delayed by one more unit time interval. Similarly, the data in fourth column R4 are processed during this period of time in the fourth partial sum-calculating unit 32-4 according to a timing which is still further delayed by another unit time interval. In order to explain this in detail, suppose that the first column data R1 are sequentially processed in the first partial sum-calculating unit 32-1 according to the order of arrangement of the first to fourth projections: P1 → P2 → P3 → P4. Then, the second column data R2 are processed in the second partial sum-calculating unit 32-2 in the sequence that is shifted by one projection relative to the processing sequence of the first column data R1 described above, for example, in the sequence of projections P2 → P3 → P4 → P1. During the same period of time, third column data R3 are processed in the third partial sum-calculating unit 32-3 in the sequence of projections P3 → P4 → P1 → P2, and fourth column data R4 are processed in the fourth partial sum-calculating unit 34-4 according to the sequence of projections P4 → P1 → P2 → P3. The data corresponding to four projections contained in each column are sequentially transmitted to the first to fourth accumulators 34-1, 34-2, 34-3 and 34-4 each time they are processed. The accumulation section 34 shown in Fig. 3 is composed of a parallel connection of the first to fourth accumulators. However, four accumulators need not be used, and only one accumulator may constitute the accumulation section 34, if the memory accesses of the adding circuit 54 provided in each accumulator are speeded up.

The operation mode of the data processing device 10 of the construction according to one embodiment of the present invention will be explained below with reference to the timing chart shown in Fig. 6. The timing chart of Fig. 6 shows the operation timings of the first to fourth partial sum-calculating units 32-1, 32-2, 32-3 and 32-4 constituting the partial sum-producing section 32 shown in Fig. 3. In Fig. 6, the symbol " is used to mean "the same as above". The analog signal which is output from the X-ray detecting section 20 included in the CT system of Fig. 1 is acquired in the data acquisition section 22 and converted into digital signals (matrix data). These matrix data are supplied through the control unit 24 to the external memory 28 to be stored therein, and are also transmitted through the control unit 24 to the data processing device 10 of the present invention. In this data processing device 10, the first column data R1 of the first to fourth projections P1, P2, P3 and P4 (Fig. 2) are sequentially added and processed in the first partial sum-calculating unit 32-1. The result of this addition output from the first partial sum-calculating unit 32-1 is stored in the partial sum memory 44. During this period of time, the second column data R2 of the first to fourth projections P1, P2, P3 and P4 are sequentially added in the second partial sum-calculating unit 32-2 according to a timing which is delayed by one unit time interval, and thereafter the result is stored in a partial sum memory provided in the partial sum-calculating unit 32-2. At this time, the third column data R3 of these projections are added in the third partial sum-calculating unit 32-3 at a timing which is further delayed by one unit time interval. The result of this addition is stored in a partial sum memory provided in the unit 32-3. Simultaneously, the fourth column data R4 of these projections are added in the fourth partial sum-calculating unit 32-4 according to a timing which is still further delayed by one unit time interval, and the result of the addition is stored in a partial sum memory included in the unit 32-4. The timing of operations of the fourth partial sum-calculating unit 34-4 corresponds to the time "4" in the timing chart of Fig. 6. The addition result data produced by each partial sum-calculating unit are transmitted to the accumulation section 34 after the completion of each addition, and the results are accumulated by this accumulation section 34. That is, the timings of transmission to the first to fourth accumulators 34-1, 34-2, 34-3 and 34-4 constituting the accumulation section 34 are relatively shifted by one unit time interval. The first partial sum-calculating unit 32-1 shifts to the next step of adding and processing fifth column data R5 (Fig. 2) of the projections P1, P2, P3 and P4, after completion of addition of the first column data of the first to fourth projections P1, P2, P3 and P4. Likewise, the second, third and fourth partial sum-calculating units 32-3, 32-3 and 32-4 respectively shift to their next steps of adding and processing sixth column data R6, seventh column data R7 and eighth column data R8 of the same projections P1, P2, P3 and P4. Thereafter, the data of every column of the first to fourth projections P1, P2, P3 and P4 are added and processed in a similar way by the partial sum-producing section 32 including the four partial sum-calculating units described above. In particular, 320th column data R320 are added in the fourth partial sum-calculating unit 32-4.

After the processing of all the column data of the first to fourth projections has been completed, the partial sum of the first data group 40-1 (Fig. 2) is calculated. After completion of the processing of the first group 40-1, the first to fourth partial sum-calculating units 32-1, 32-2, 32-3 and 32-4 sequentially add and process the remaining data groups 40-1, . . ., 40-150 in a similar manner as described above, and output the respective partial sums thereof. By sequentially accumulating these partial sums, the final value of all the matrix data divided into 150 data groups 40-1, 40-2, . . ., 40-150 can be obtained, and the image reconstruction according to the back-projection technique is performed.

As described above, in accordance with the present invention, an aggregate of matrix data corresponding to the projection data is divided into a predetermined number of groups and the partial sum of each data group is calculated. The total sum of all the projection data is obtained by sequentially accumulating these partial sums. Therefore, the number of access operations to the accumulation memory can be reduced. For example, if the number of projections is set to 600, at least 600 access operations have been required in the accumulation memory provided in a conventional data processing device. However, when 600 projections are divided into 150 data groups with one group being defined to contain four projections as in the embodiment of the present invention, the number of accesses can be reduced to about one-fourth, that is, 150. Consequently, the time spent to process the data can be shortened, as a result of which the data processing for the CT system can be sped up. Thus, the data processing device of the present invention is suitable for real time processing in the back-projection technique and is therefore extremely effective in further speeding up the steps of reconstructing tomograms.

Furthermore, according to the present invention, the number of image memories provided in the accumulation section can be reduced to the number of projections corresponding to one group (i.e. four in the embodiment described above). As a result, the construction of the data processing device can be simplified and made more economical.

Claims

1. A data processing device (10) which is applied to a computed tomography system for examining at least one portion of an object (18) by utilizing radiation such as X-rays (14) and which processes data from a plurality of projections for image reconstruction, wherein the computed tomography system includes detector means (20), positioned opposite a radiation source means (12) through the object (18), for detecting radiation (14) output from said radiation source means (12), and means (24) for effecting a relative rotation between the object (18) and said radiation source means (12) about an axis of rotation, said data processing device (10) comprising first processing means (30) for successively generating N sets of back-projection matrix data based on outputs derived from said detector means (20) at N angles of said rotation, where N represents a positive integer, characterized in that said data processing device comprises also second processing means (32), connected to said first processing means (30), for summing successive n sets of back-projection matrix data (40-1) among said N sets of back-projection matrix data (36), and for successively providing summed data, where n is a positive integer, image memory means (56) for temporarily storing calculation result data; and third processing means (34) connected to said second processing means (32) and said image memory means (56) for successively receiving the summed data for k times (k = N/n), where k is a positive integer and sequentially adding said summed data in such a manner that said third processing means (34) repetitiously performs an arithmetic operation of adding that summed data which is currently supplied to said third processing means (34) to that summed data which is currently stored in said image memory means (56) and replacing said summed data stored in said image memory means (56) with new summed data resulting from said addition of said third processing means (34), thereby finally permitting said image memory means (56) to store a final value of said N sets of back-projection matrix data (36), whereby the number of write-operations of said image memory means (56), which are required to attain said N sets of back-projection matrix data (36), is reduced substantially to N/n so that a back-projection time necessary for image reconstruction is reduced, accordingly.

2. A data processing device according to claim 1, characterized in that said first processing means (30) comprises n sets of data generators (30-1, 30-2, 30-3, 30-4) which sequentially supply k groups of block data (40-1 to 40-150) to said second processing means (32) in an increasing order of the number of the block data (40-1 to 40-150).

3. A data processing device according to claim 2, characterized in that said second processing means (32) comprises n sets of adding sections (32-1, 32-2, 32-3, 32-4) connected in parallel with each other, for respectively summing column data contained in a predetermined column of the n sets of matrix data (P1, P2, P3, P4), each of said adding sections including an adding circuit (42), a memory (44) and a multiplexer (46).

4. A data processing device according to claim 3, characterized in that said adding circuit (42) has a first input connected to one of said data generators (30-1, 30-2, 30-3, 30-4), a second input, and an output connected to the second input through said memory (44) and said multiplexer (46).

5. A data processing device according to claim 4, characterized in that said third processing means (34) comprises adding circuit means (34-1, 34-2, 34-3, 34-4) connected to said second processing means (32) and said image memory means (56), for permitting said image memory means (56) to temporarily store that block data (40-1) which is supplied to said third processing means (34) and corresponds to a partial sum of said n sets of back-projection matrix data (P1, P2, P3, P4), accessing said image memory means (56) to read out said stored block data when successive block data (40-2) is supplied from said second processing means (32), adding said successive block data (40-2) to said previously stored block data (40-1) and permitting said image memory means (56) to store new data resulting from said addition of said adding circuit means (34-1 to 34-4) in place of said previously stored block data (40-1).

6. A data processing device according to claim 5, characterized in that said adding circuit means includes n sets of accumulators (34-1, 34-2, 34-3, 34-4) each of which includes an adding circuit (54) and an image memory serving as said image memory means (56).

7. A data processing device according to claim

3, characterized in that while a first adding section (32-1) among said n adding sections (32-1, 32-2, 32-3, 32-4) of said second processing means (32) adds first column data (R1) of said one data group (40-1) among said k data groups (40-1, 40-2, ..., 40-150), a second adding section (32-2) of said n adding sections (32-1, 32-2, 32-3, 32-4) adds second column data (R2) of said data group (40-1), and (n − 1)th adding section (32-3) adds (n − 1)th column data (R3) of said data group (40-1), and an nth adding section (32-4) adds nth column data (R4) of said data group (40-1).

8. A data processing device according to claim 8, characterized in that said first adding section (32-1) of said second processing means (32) shifts to a step of adding (n + 1)th column data of said data group (40-1) after it has completed the addition of said first column data (R1) of the data group (40-1), while said second adding section (32-2), said (n − 1)th adding section (32-3) and said nth adding (32-4) section simultaneously shift to steps of adding (n + 2)th column data, (2nd − 1)th column data and 2nth column data of said data group (40-1), respectively.

9. A data processing device according to claim 5, characterized in that said adding circuit means (34-1 to 34-4) includes at most n accumulation sections (34-1, 34-2, 34-3, 34-4) provided in parallel with each other for sequentially receiving said partial sum data from said second processing means (32) to sequentially accumulate said partial sum data.

Patentansprüche

1. Datenverarbeitungseinrichtung (10) für ein rechnergesteuertes (-gestütztes) Tomographiesystem zum Untersuchen mindestens eines Bereichs eines (Untersuchungs-) Objekts (18) mittels Strahlung, wie Röntgenstrahlung (14), und zum Verarbeiten von Daten von einer Anzahl von Projektionen für Bildrekonstruktion, wobei das rechnergesteuerte Tomographiesystem eine über das Objekt (18) einer Strahlungsquelleneinheit (12) gegenüberstehend angeordnete Detektoreinheit (20) zum Erfassen der von der Strahlungsquelleneinheit (12) abgegebenen Strahlung (14) und eine Einrichtung (24) zur Hervorbringung einer Relativdrehung zwischen dem Objekt (18) und der Strahlungsquelleneinheit (12) um eine Drehachse herum aufweist und die Datenverarbeitungsinrichtung (10) eine erste Verarbeitungseinheit (30) zum aufeinanderfolgenden Erzeugen von N Sätzen von Durch- oder Rückprojektionsmatrixdaten auf der Grundlage von Ausgangssignalen von der Detektoreinheit (20) unter N Drehwinklen, mit N = eine positive ganze Zahl, umfaßt,

dadurch gekennzeichnet,

daß die Datenverarbeitungseinrichtung außerdem eine mit der ersten Verarbeitungseinheit (30) verbundene zweite Verarbeitungseinheit (32) zum Summieren von n aufeinanderfolgenden Sätzen von Rückprojektionsmatrixdaten (40-1) aus den N Sätzen von Rückprojektionsmatrixdaten (36) und zum aufeinanderfolgenden Liefern von summierten Daten, mit n = eine positive ganze Zahl, eine Bildspeichereinheit (56) zum vorübergehenden Speichern oder Zwischenspeichern von Rechenergebnisdaten sowie eine mit der zweiten Verarbeitungseinheit (32) und der Bildspeichereinheit (56) verbundene dritte Verarbeitungseinheit (34) zum aufeinanderfolgenden k-maligen (k = N/n), mit k = eine positive ganze Zahl, Abnehmen der summierten Daten und zum sequentiellen Addieren der summierten Daten in der Weise, daß die dritte Verarbeitungseinheit (34) wiederholt eine arithmetische oder Rechenoperation eines Addierens der summierten Daten, die augenblicklich der dritten Berarbeitungseinheit (34) geliefert werden, zu den summierten Daten, die augenblicklich in der Bildspeichereinheit (56) gespeichert sind, ausführt und die in der Bildspeichereinheit (56) gespeicherten summierten Daten durch neue, aus der Addition durch die dritte Verarbeitungseinheit (34) resultierende summierte Daten ersetzt, um dammit letztlich die Bildspeichereinheit (56) eine Endgröße der N Sätze von Rückprojektionsmatrixdaten (36) speichern zu lassen, aufweist wodurch die zur Gewinnung der N Sätze von Rückprojektionsmatrixdaten (36) erforderliche Zahl von Einschreiboperationen der Bildspeichereinheit (56) praktisch auf N/n reduziert wird, so daß sich die für die Bildrekonstruktion nötige Rückprojektionszeit ebenfalls entsprechend verkürzt.

2. Datenverarbeitungseinrichtung nach Anspruch 1, dadurch gekennzeichnet, daß die erste Verarbeitungseinheit (30) n Sätze von Datengeneratoren (30-1), (30-2, 30-3, 30-4) aufweist, die sequentiell k Gruppen von Blockdaten (40-1 bis 40-150) zur zweiten Verarbeitungseinheit (32) in einer ansteigenden Reihenfolge der Zahl der Blockdaten (40-1 bis 40-150) liefern.

3. Datenverarbeitungseinrichtung nach Anspruch 2, dadurch gekennzeichnet, daß die zweite Verarbeitungseinheit (32) n Sätze von zueinander parallelgeschalteten Addierteilen (32-1, 32-2, 32-3, 32-4) zum jeweiligen Summieren von in einer vorbestimmten Spalte der n Sätze von Matrixdaten (P1, P2, P3, P4) enthaltenen Spaltendaten aufweist und jeder Addierteil einen Addierkreis (42), einen Speicher (44) und einen Multiplexer (46) umfaßt.

4. Datenverarbeitungseinrichtung nach Anspruch 3, dadurch gekennzeichnet, daß der Addierkreis (42) einen ersten, mit einem der Datengeneratoren (30-1, 30-2, 30-3, 30-4) verbundenen Eingang, einen zweiten Eingang und einen über den Speicher (44) und den Multiplexer (46) mit dem zweiten Eingang verbundenen Ausgang aufweist.

5. Datenverarbeitungseinrichtung nach Anspruch 4, dadurch gekennzeichnet, daß die dritte Verarbeitungseinheit (34) mit der zweiten Verarbeitungseinheit (32) und der Bildspeichereinheit (56) verbundene Addierkreiseinheiten (34-1, 34-2, 34-3, 34-4) aufweist, um der Bildspeichereinheit (56) die Zwischenspeicherung der von der dritten Verarbeitungseinheit (34) gelieferten und

einer Teilsumme der n Sätze von Rückprojectionsmatrixdaten (P1, P2, P3, P4) entsprechenden Blockdaten (40-1) zu erlauben, einen Zugriff zur Bildspeichereinheit (56) zum Auslesen der gespeicherten Blockdaten, wenn aufeinanderfolgende Blockdaten (40-2) von der zweiten Verarbeitungseinheit (32) geliefert werden, herzustellen, die aufeinanderfolgenden Blockdaten (40-2) zu den vorher gespeicherten Blockdaten (40-1) hinzuzuaddieren und der Bildspeichereinheit (56) die Speicherung der neuen, von der Addition durch die Addierkreiseinheiten (34-1 bis 34-4) resultierenden Daten anstelle der vorher gespeicherten Blockdaten (40-1) zu erlauben.

6. Datenverarbeitungseinrichtung nach Anspruch 5, dadurch gekennzeichnet, daß die Addierkreiseinheiten n Sätze von Akkumulatoren (34-1, 34-2, 34-3, 34-4) umfassen, von denen jeder einen Addierkreis (54) und einen als Bildspeichereinheit (56) dienenden Bildspeicher aufweist.

7. Datenverarbeitungseinrichtung nach Anspruch 3, dadurch gekennzeichnet, daß dann, während ein erster Addierteil (32-1) von den n Addierteilen (32-1, 32-2, 32-3, 32-4) der zweiten Verarbeitungseinheit (32) erste Spaltendaten (R1) der einen Datengruppe (40-1) unter den k Datengruppen (40-1, 40-2, . . ., 40-150) addiert, ein zweiter Addierteil (32-2) der n Addierteile (32-1, 32-2, 32-3, 32-4) zweite Spaltendaten (R2) der Datengruppe (40-1) addiert, ein (n-1)-ter Addierteil (32-3) (n-1)-te Spaltendaten (R3) der Datengruppe (40-1) addiert und ein n-ter Addierteil (32-4) n-te Spaltendaten (R4) der Datengruppe (40-1) addiert.

8. Datenverarbeitungseinrichtung nach Anspruch 7, dadurch gekennzeichnet, daß der erste Addierteil (32-1) der zweiten Verarbeitungseinheit (32) auf einen Schritt des Addierens von (n + 1)-ten Spaltendaten der Datengruppe (40-1) übergeht, nachdem er die Addition der ersten Spaltendaten (R1) der Datengruppe (40-1) ausgeführt hat, während der zweite Addierteil (32-2), der (n-1)te Addierteil (32-3) und der n-te Addierteil (32-4) gleichzeitig auf die Schritte des Addierens der (n + 2)-ten Spaltendaten, der (2n − 1)-ten Spaltendaten bzw. der 2n-ten Spaltendaten der Datengruppe (40-1) übergehen.

9. Datenberarbeitungseinrichtung nach Anspruch 5, dadurch gekennzeichnet, daß die Addierkreiseinheiten (34-1 bis 34-4) höchstens n parallel zueinander angeordnete Akkumulatorteile (34-1, 34-2, 34-3, 34-4) zum sequentiellen Abnehmen der Teilsummendaten von der zweiten Verarbeitungseinheit (32) zum sequentiellen Akkumulieren oder Aufspeichern dieser Teilsummendaten aufweisen.

Revendications

1. Dispositif de traitement de données (10) qui est appliqué à un système de tomographie par caculateur pour examiner au moins une partie d'un objet (18) en utilisant une radiation telle que des rayons X (14) et qui traite des données provenant d'un ensemble de projections pour une reconstitution d'image, dans lequel le système de tomographie par calculateur comprend des moyens détecteurs (20), placés à l'opposé d'une source de radiation (12) à travers (20), placés à l'opposé d'une source de radiation (12) à travers l'objet (18), pour détecter la radiation (14) en sortie de la source de radiation (12), et un moyen (24) pour effectuer une rotation relative entre l'objet (18) et la source de radiation (12) autour d'un axe de rotation, le dispositif de traitement de données (10) comprenant un premier moyen de traitement (30) pour engendrer successivement N groupes de données matricielles de rétroprojection en fonction de signaux de sortie dérivés des moyens détecteurs (20) à N angles de la rotation, N représentant un entier positif, caractérisé en ce que le dispositif de traitement de données comprend également un deuxième moyen de traitement (32), connectée au premier moyen de traitement (30), pour faire la somme de n groupes successifs de données matricielles de rétroprojection (40-1) parmi les N groupes de donnés matricielles de rétroprojection (36), et pour fournir successivement les données additionnées, n étant un entier positif, à un moyen à mémoire d'image (56) servant à mémoriser temporairement les données résultantes d'un calcul; et un troisième moyen de traitement (34) connecté au deuxième moyen de traitement (32) et au moyen à mémoire d'image (56) pour recevoir successivement les données additionnées k fois (k = N/n), k étant un entier positif, et pour additionner séquentiellement les données additionnées de telle manière que le troisième moyen de traitement (34) exécute de façon répétée un opération arithmétique d'addition des données additionnées qui sont alors fournies au troisième moyen de traitement (34) et des données additionnées qui sont alors mémorisées dans le moyen à mémoire d'image (56) et pour remplacer les données additionnées mémorisées dans le moyen à mémoire d'image (56) par de nouvelles données additionnées résultant de l'addition faite par le troisième moyen de traitement (34), ce qui permet finalement au moyen à mémoire d'image (56) de mémoriser une valeur finale des N groupes de données matricielles de rétroprojection (36), en réduisant ainsi le nombre d'opérations d'écriture du moyen à mémoire d'image (56), qui sont nécessaires pour atteindre les N groupes de données matricielles de rétroprojection (36) essentiellement jusqu'à N/n, de sorte qu'un temps de rétroprojection nécessaire pour une reconstitution d'image est réduit en conséquence.

2. Dispositif de traitement de données selon la revendication 1, caractérisé en ce que le premier moyen de traitement (30) comprend n groupes de générateurs de données (30-1, 30-2, 30-3, 30-4) qui fournissent séquentiellement k groupes de données de bloc (40-1 à 40-150) au deuxième moyen de traitement (32) dans un ordre croissant du nombre des données de bloc (40-1 à 40-150).

3. Dispositif de traitement de données selon la revendication 2, caractérisé en ce que le deuxième moyen de traitement (32) comprend n

groupes de sections d'addition (32-1, 32-2, 32-3, 32-4) connectées en parallèle entre elles, pour faire respectivement la somme de données de colonne contenues dans une colonne prédéterminée des n groupes de données matricielles (P1, P2, P3, P4), chacune des sections d'addition incluant un circuit d'addition (42), une mémoire (44) et un multiplexeur (46).

4. Dispositif de traitement de données selon la revendication 3, caractérisé en ce que le circuit d'addition (42) comporte une première entrée connectée à un des génerateurs de données (30-1, 30-2, 30-3, 30-4), une seconde entrée, et une sortie connectée à la seconde entrée par l'intermédiaire de la mémoire (44) et du multiplexeur (46).

5. Dispositif de traitement de données selon la revendication 4, caractérisé en ce que le troisième moyen de traitement (34) comprend des moyens à circuit d'addition (34-1, 34-2, 34-3, 34-4) connectés au deuxième moyen de traitement (32) et au moyen à mémoire d'image (56), pour permettre au moyen à mémoire d'image (56) de mémoriser temporairement les données de bloc (40-1) qui sont fournies au troisième moyen de traitement (34) et correspondent à une somme partielle des n groupes de données matricielles de rétroprojection (P1, P2, P3, P4), pour avoir accès au moyen à mémoire d'image (56) en vue de lire les données de bloc mémorisées quand des données de bloc successives (40-2) sont fournies par le deuxième moyen de traitement (32), pour additionner les données de bloc successives (40-2) avec le données de bloc précédemment mémorisées (40-1) et pour permettre au moyen à mémoire d'image (56) de mémoriser de nouvelles données résultantes de l'addition faite par les moyens à circuit d'addition (34-1 à 34-4) à la place des données de bloc précédemment mémorisées (40-1).

6. Dispositif de traitement de données selon la revendication 5, caractérisé en ce que les moyens à circuit d'addition comprennent n groupes d'accumulateurs (34-1, 34-2, 34-3, 34-4) dont chacun comprend un circuit d'addition (54) et une mémoire d'image servant de moyen à mémoire d'image (56).

7. Dispositif de traitement de données selon la revendication 3, caractérisé en ce que, alors qu'une première section d'addition (32-1) parmi les n sections d'addition (32-1, 32-2, 32-3, 32-4) du deuxième moyen de traitement (32) additionne des premières données de colonne (R1) dudit groupe de données (40-1) parmi les k groupes de données (40-1, 40-2, . . ., 40-150), une deuxième section d'addition (32-2) des n sections d'addition (32-1, 32-2, 32-3, 32-4) additionne des deuxièmes données de colonne (R2) du groupe de données (40-1), et une $(n-1)^{ieme}$ section d'addition (32-3) additionne des $(n-1)^{iemes}$ données de colonne (R3) du groupe de données (40-1), et une n^{ieme} section d'addition (32-4) additionne des n^{iemes} données de colonne (R4) du groupe de données (40-1).

8. Dispositif de traitement de données selon la revendication 8, caractérisé en ce que la première section d'addition (32-1) du deuxième moyen de traitement (32) se décale jusqu'à une phase d'addition de $(n+1)^{iemes}$ données de colonne du groupe de données (40-1) après avoir terminé l'addition des premières données de colonne (R1) du groupe de données (40-1), alors que la deuxième section d'addition (32-2), la $(n-1)^{ieme}$ section d'addition (32-3) et la n^{ieme} section d'addition (32-4) se décalent simultanément jusqu'à des phases d'addition de $(n+2)^{iemes}$ données de colonne, de $(2n-1)^{iemes}$ données de colonne et de $2n^{iemes}$ données de colonne du groupe de données (40-1), respectivement.

9. Dispositif de traitement de données selon la revendication 5, caractérisé en ce que les moyens à circuit d'addition (34-1 à 34-4) comprennent au plus n sections d'accumulation (34-1, 34-2, 34-3, 34-4) prévues en parallèle entre elles pour recevoir séquentiellement les données de somme partielle du deuxième moyen de traitement (32) en vue d'accumuler séquentiellement les données de somme partielle.

FIG. 1

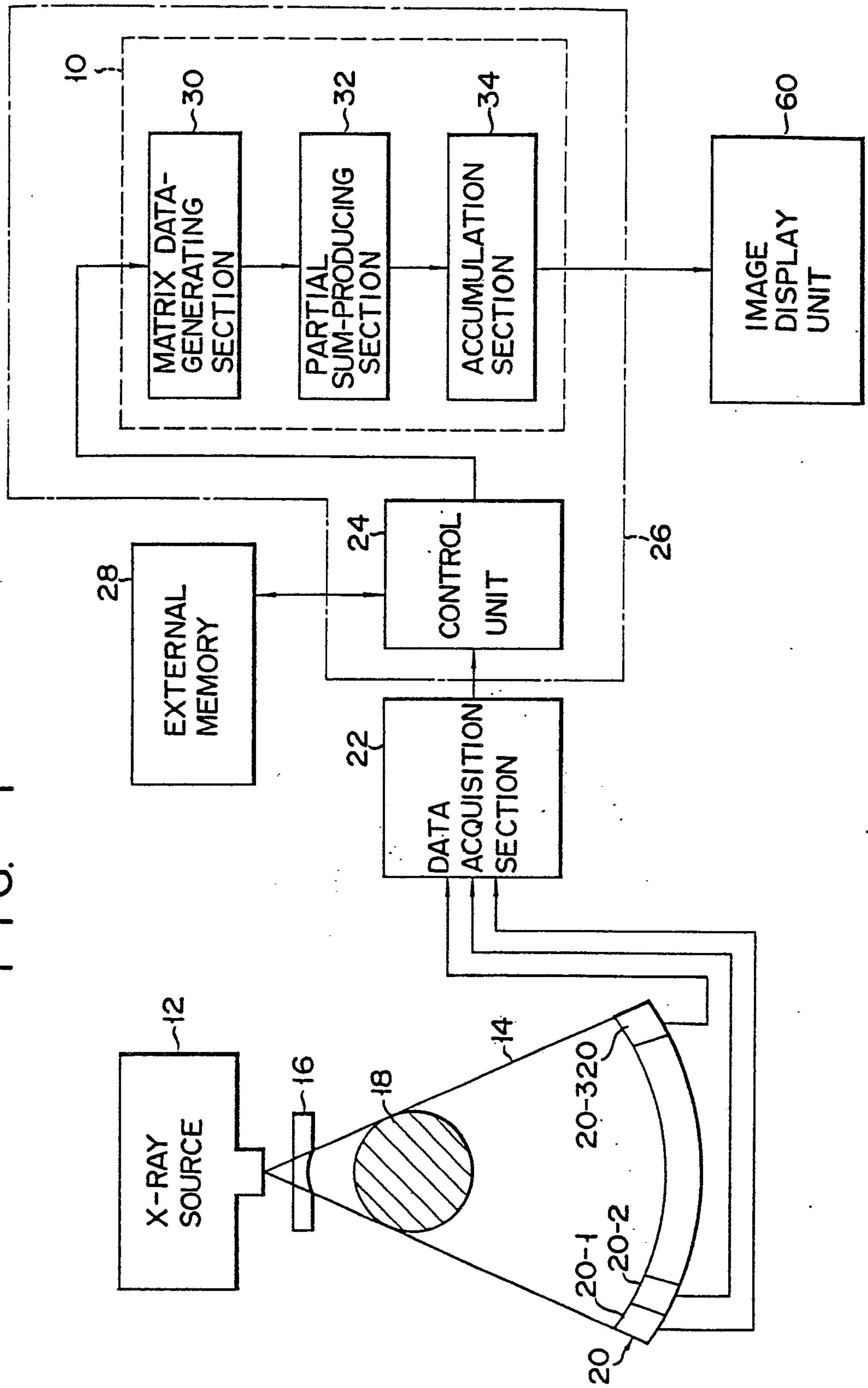
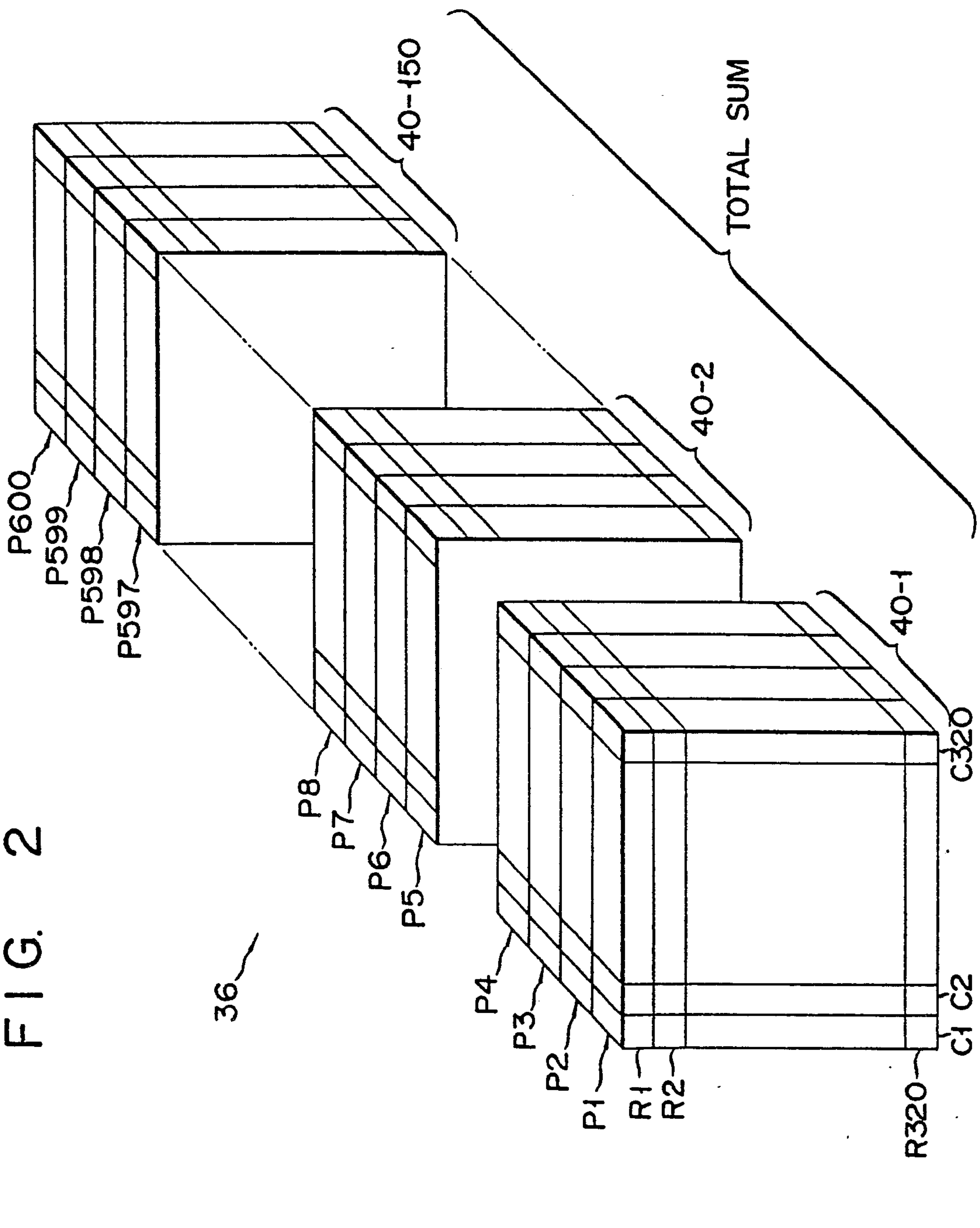

10
30
MATRIX DATA-GENERATING SECTION
32
PARTIAL SUM-PRODUCING SECTION
34
ACCUMULATION SECTION
60
IMAGE DISPLAY UNIT
24
CONTROL UNIT
26
28
EXTERNAL MEMORY
22
DATA ACQUISITION SECTION
12
X-RAY SOURCE
16
18
14
20-320
20-1
20-2
20

FIG. 2



36
P600
P599
P598
P597
40-150
TOTAL SUM
40-2
P8
P7
P6
P5
40-1
P4
P3
P2
P1
R1
R2
R320
C1
C2
C320

FIG. 3

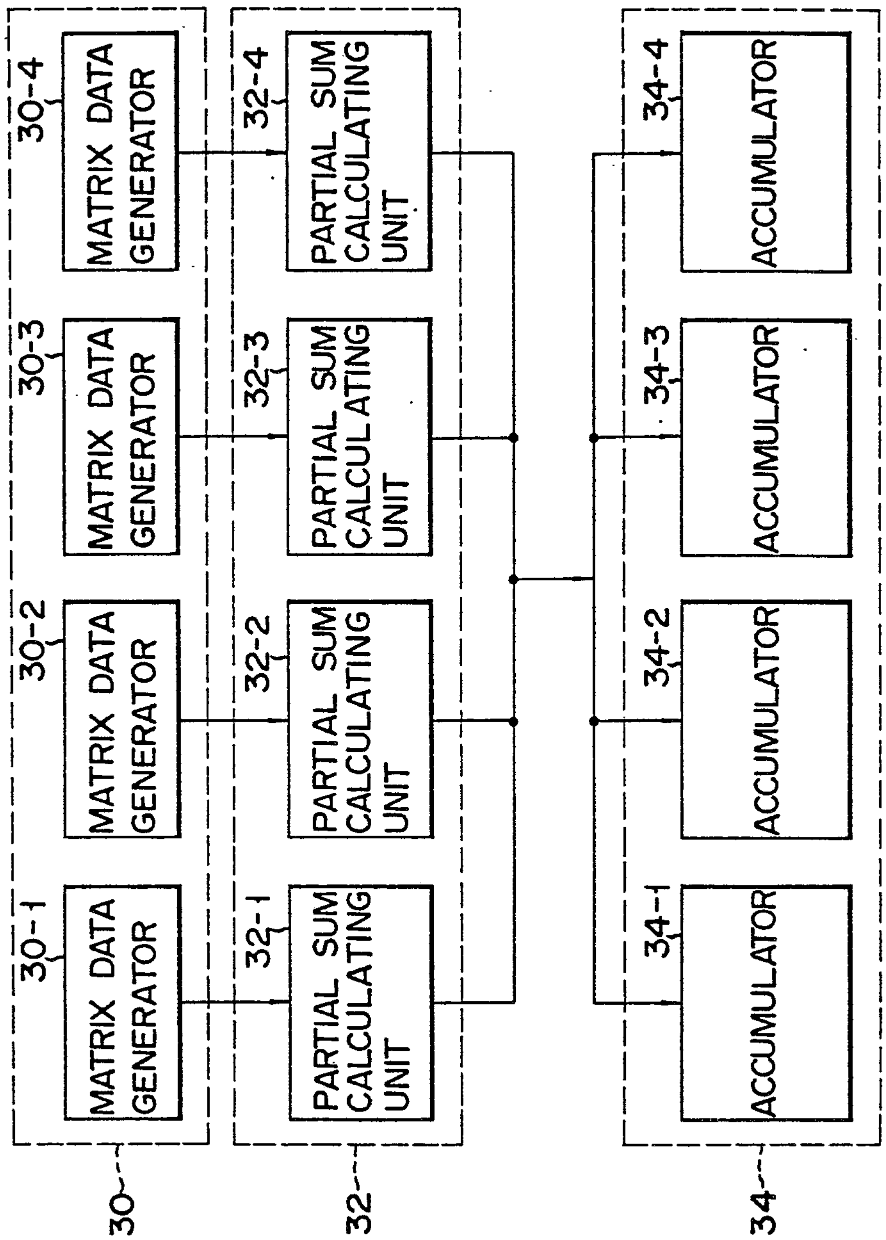

30-1
MATRIX DATA GENERATOR
30-2
MATRIX DATA GENERATOR
30-3
MATRIX DATA GENERATOR
30-4
MATRIX DATA GENERATOR
32-1
PARTIAL SUM CALCULATING UNIT
32-2
PARTIAL SUM CALCULATING UNIT
32-3
PARTIAL SUM CALCULATING UNIT
32-4
PARTIAL SUM CALCULATING UNIT
34-1
ACCUMULATOR
34-2
ACCUMULATOR
34-3
ACCUMULATOR
34-4
ACCUMULATOR
30
32
34

FIG. 4

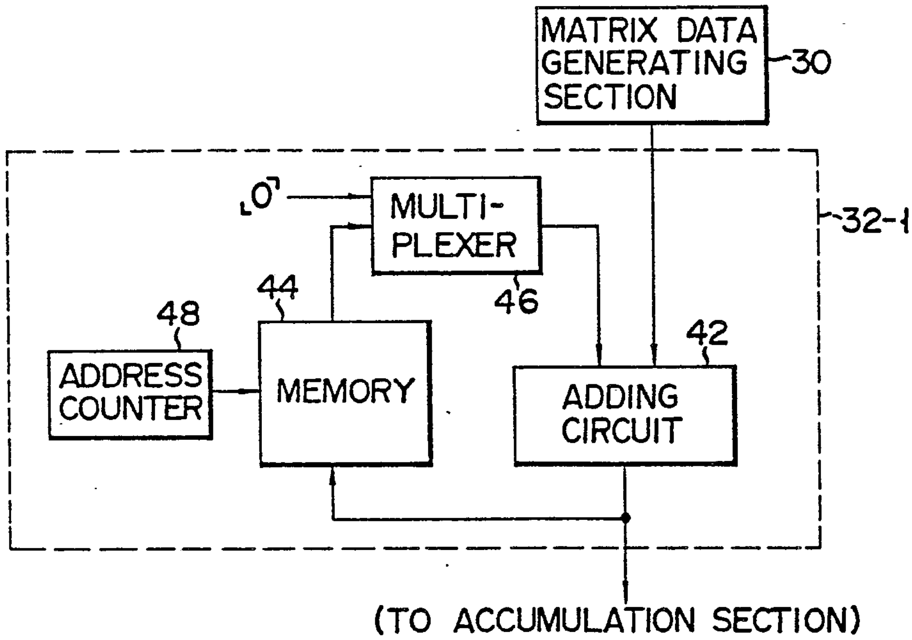

MATRIX DATA GENERATING SECTION
30
"0"
MULTI-PLEXER
32-1
44
46
48
42
ADDRESS COUNTER
MEMORY
ADDING CIRCUIT
(TO ACCUMULATION SECTION)

FIG. 5

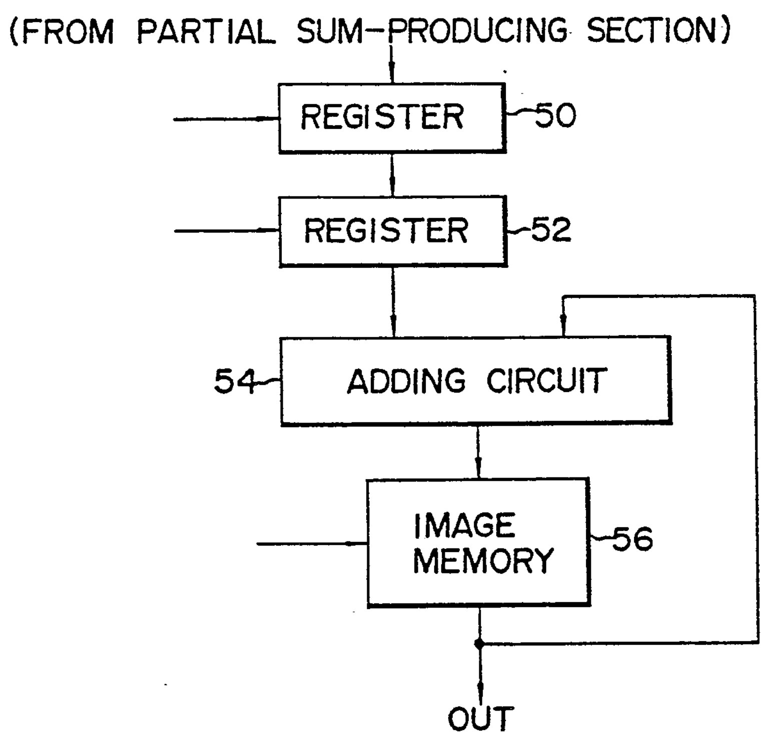

(FROM PARTIAL SUM-PRODUCING SECTION)
REGISTER
50
REGISTER
52
54
ADDING CIRCUIT
IMAGE MEMORY
56
OUT

FIG. 6

TIME	1ST PARTIAL SUM CALCULATING UNIT		2ND PARTIAL SUM CALCULATING UNIT		3RD PARTIAL SUM CALCULATING UNIT		4TH PARTIAL SUM CALCULATING UNIT	
	ROW NO.	PROJECTION NO.	ROW NO.	PROJECTION NO.	ROW NO.	PROJECTION NO.	ROW NO.	PROJECTION NO.
1	1	1	—	—	—	—	—	—
2	"	2	2	1	—	—	—	—
3	"	3	"	2	3	1	—	—
4	"	4	"	3	"	2	4	1
5	5	1	"	4	"	3	"	2
6	"	2	6	1	"	4	"	3
7	"	3	"	2	7	1	"	4
8	"	4	"	3	"	2	8	1
9	9	1	"	4	"	3	"	2
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
313	313	1						
314	"	2	314	1				
315	"	3	"	2	315	1		
316	"	4	"	3	"	2	316	1
317	317	1	"	4	"	3	"	2
318	"	2	318	1	"	4	"	3
319	"	3	"	2	319	1	"	4
320	"	4	"	3	"	2	320	1
321	—	—	"	4	"	3	"	2
322	—	—	—	—	"	4	"	3
323	—	—	—	—	—	—	"	4